



**Water Treatment Technology
Feasibility Support Document
For Chemical Contaminants
In Support of EPA Six-Year Review of
National Primary Drinking Water
Regulations**

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National Primary Drinking Water Regulations**

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Office of Ground Water and Drinking Water
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This report is issued in support of the preliminary revise/not revise decisions for the EPA Six-Year Review Notice of Intent. It is intended for public comment and does not represent final agency policy. EPA expects to issue a final version of this report with the publication of the final EPA notice in 2002, reflecting corrections due to public comment on the preliminary notice and the supporting documents.

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I. INTRODUCTION

This water treatment technology feasibility support document summarizes available treatment information in support of the U.S. Environmental Protection Agency (EPA) review of national primary drinking water regulations (NPDWRs). A review of NPDWRs is required at least once every six years under Section 1412(b)(9) of the federal Safe Drinking Water Act, as amended in 1996. The subject Six-Year Review of NPDWRs addresses 68 regulated chemical contaminants, i.e., most of the chemical contaminants regulated prior to 1996. A formal EPA decision to revise or not revise NPDWRs is expected in the latter part of 2002.

EPA sets non-enforceable maximum contaminant level goals (MCLGs), based on health effects information and related risk analyses. EPA enforceable standards include maximum contaminant levels (MCLs) and treatment techniques (TT) which are dependent upon EPA-documented treatment feasibility assessments and other considerations.

EPA developed a systematic approach, or protocol, for the review of these NPDWRs.¹ Several technical analyses have been accomplished by EPA to complete the first round of review of all pre-1996 chemical NPDWRs. The analyses address human health effects, analytical methods, treatment technologies, chemical occurrence, and other aspects related to the regulations. These analyses have been individually conducted in phases, as appropriate, and are documented separately.

Results of the above-cited analyses were used by EPA to make a preliminary determination as to which NPDWRs may be subject to revision, i.e., the analyses identified possible or potential candidates for revision based upon the review of new scientific data. In order to complete the subject six-year review in a timely manner, the Agency initiated this preliminary review of water treatment technology, to determine the feasibility of any potential revisions to the NPDWRs. Ultimately EPA conducted a greater number of such feasibility assessments than required once the Agency had sufficient data on all aspects of the Six-Year Review to make a decision on revising, or not revising, standards.

The review of treatment feasibility was completed on individual NPDWRs if either of the following conditions applied, as per the above-cited protocol:

- a health effects technical review suggests a potential change to the MCLG (these were *five* in number at the inception of this review);
- a health effects assessment is not in process (or scheduled) for the contaminant and one of the following conditions applies: (1) the analytical feasibility assessment suggests a potential revision to the regulated level (*15* in number at the inception); (2) the NPDWR is a TT-type rule (*four* in number at the inception).

In addition, EPA reviewed treatment feasibility information for NPDWRs for which BAT or TT requirements are not clear or incorrectly specified (*one* NPDWR was identified).

Table 1 below lists the chemical NPDWRs which are the subject of this report:

¹ EPA. Protocol for Review of Existing National Primary Drinking Water Regulations. Draft report, published at time of Six-Year Review Notice of Intent, March 2002.

Table 1. Chemical NPDWRs Included in This Treatment Feasibility Support Document

5 Contaminants Initially Identified Under the Six-Year Health Effects Review			
1	Beryllium	4	Oxamyl
2	Chromium	5	Picloram
3	Fluoride		
15 Contaminants for Which Analytical Feasibility Assessments Suggested a Potential Change			
1	Benzene	9	Heptachlor epoxide
2	Carbon tetrachloride	10	Hexachlorobenzene
3	Chlordane	11	Tetrachloroethylene ("perc")
4	1,2-Dibromo-3-chloropropane (DBCP)	12	Thallium
5	1,2-Dichloroethane	13	Toxaphene
6	Dichloromethane	14	1,1,2-Trichloroethane
7	1,2-Dichloropropane	15	Trichloroethylene
4 Contaminants Regulated by TT Requirements			
1	Acrylamide	4	Lead
2	Copper		
3	Epichlorohydrin		
Contaminant for Which BAT is Not Clear or Incorrectly Specified			
Cyanide			

This document primarily discusses best available technologies (BATs) specified by EPA to meet MCLs, and technologies to meet TT-type rules. Supplemental information is provided on small systems compliance technologies and other related treatment information. In addition, EPA has also included, as appropriate, available EPA data on treatment technologies in place at public water supplies (community type), i.e., baseline treatment characteristics; discussion of the feasibility of adding treatment or modifications to existing in-place treatments; discussion of treatment wastes as appropriate; and, preliminary characterization of research areas that may be pursued prior to revising a NPDWR, as applicable. EPA is relying on available scientific and engineering data to support this process. The end result of each contaminant-specific review which follows is a determination regarding the feasibility of treatment technology, i.e., a determination of whether treatment would pose a limitation should EPA pursue a revision to a specified standard.

References cited in this report are listed in the final section of this report. These sources have been reviewed previously. Some of these are relatively new sources while others were used in support of the subject NPDWRs which were promulgated in the period of 1985-1992.

The treatment review contains some recent information related to the EPA-estimated occurrence of the subject contaminants, i.e., levels above current MCL and other threshold values. These EPA occurrence estimates are available and are in *draft* status and subject to change; these data provide indication of contaminant levels in drinking water and may be relevant in the assessment of feasibility of treatment or of making treatment modifications, if applicable. Since no potential, i.e., 'revised,' maximum contaminant levels (MCLs) for the subject contaminants have been considered by EPA, this support document does not contain nor assume any particular revised MCL values. The purpose of this report is to review available information on treatment feasibility in anticipation of any potential EPA revise/not revise decisions related to the NPDWRs.

As mentioned above, this treatment technology document identifies areas of water treatment research which may be required if EPA were to consider revisions to a standard. These are identified in Sections II and III, in relation to chemical MCL and TT-type rules, respectively. Section IV, related to MCL-type rules for which analytical assessment indicated the potential for lowering a standard, does not contain research suggestions, as none have been identified. Discussion of potential water treatment technology research needs in this phase of the review of NPDWRs is provided to inform the EPA drinking water program and the public. This information would be considered within EPA's research planning process, with the longer-term aim of strengthening regulations such that they may be more effective and implementable.

Research suggestions may also be aimed at defining new technologies that are emerging in the field, and for qualifying their possible application to specific NPDWRs. Ideally, such technologies would offer specific advantages, such as lower-cost, and/or ease in operation and maintenance. They may be specifically targeted for use by certain types of water systems, e.g., small water systems. Other research suggestions may be aimed at improving established BATs or TTs, in light of recently experienced or hypothesized treatment problems. Potential research areas are indicated at the end of each chemical discussion, as appropriate.

II. Treatment review for contaminants (MCL-type) identified as possible candidates for revision based on EPA health effects technical review

BERYLLIUM

Recent EPA occurrence analyses indicate beryllium occurrence in public water systems based on a sampling of 16 States [USEPA 2002, *draft*]. Based on these analyses which included estimated system mean concentrations, EPA estimates indicate a total 0.079 percent water systems within these States may exceed the threshold of 0.004 mg/L, i.e., the current MCL for beryllium. Additional occurrence estimates may be found in the above-cited 2002 EPA draft report.

The current BATs for beryllium removal include activated alumina, ion exchange, lime softening, coagulation/filtration and reverse osmosis [USEPA, 1990b, 1990c, 1992]. Compliance technology for small systems includes these same five BATs, plus POU-RO, POU-IX for small systems [USEPA 1998b]. Removal efficiencies for the above-cited BATs range from 80% to 99%. Treatment technologies were discussed by EPA in its technical support documentation on beryllium [USEPA, 1990b]. If a treatment plant were to require upgrading, additional IX contact units may be added, POU treatment installed, or a modification to precipitative processes added as appropriate. The preliminary assessment is that treatment technology would not pose a limitation should EPA pursue a revision to this standard.

Where treatment is currently in place, for this contaminant and possibly for others, it is likely to be operating and valued for other beneficial effects, e.g., for reduction of hardness or other common impurities. However, EPA does not have data indicating to what extent this may occur and thus its significance, therefore the Agency is making no assessment as to whether treatment in place would be maintained or discontinued in the event of the MCL for beryllium being revised.

CHROMIUM (TOTAL)

Treatment technology:

Recent EPA occurrence analyses indicate chromium occurrence in public water systems based on a sampling of 16 States [USEPA 2002, *draft*]. Based on these analyses which included estimated system mean concentrations, EPA estimates indicate that 1 water system (credible interval of 0-3) within these States may exceed the threshold of 0.1 mg/L, i.e., the current MCL for total chromium; in addition, EPA estimates indicate a total 7 systems (credible interval of 3-13) within these States may exceed the threshold of 0.05 mg/L. Additional occurrence estimates may be found in the above-cited 2002 EPA draft report.

In publishing the 1989 proposed and 1991 final chromium standard [USEPA, 1989 and USEPA 1991a] the Agency discussed best available technologies (BATs) which include:

- ion exchange (IX): 80 to 96 % efficiency
- lime softening (LS) for Chromium III only: 72 to 99% efficiency
- coagulation/filtration (CF): 90 to 99% efficiency
- reverse osmosis (RO): 82 to 97% efficiency

Due to the ionic properties of the two chromium species in water, Cr III and Cr VI, there is a differentiation in BAT specification which may affect treatment selection. Cr III and Cr VI exist in water in cationic and anionic valence states, respectively. LS treatment is excluded as a BAT for anionic Cr VI. Regarding the coagulation/filtration option, the choice of coagulant will impact Cr III and Cr VI removal: ferric sulfate and alum are effective for removal of Cr III while ferrous sulfate is effective for removal of Cr VI. Regarding ion exchange, a cation exchange resin is required for Cr III, while an anionic resin is required for Cr VI. Therefore, prior to use (or modification) of LS, IX, or CF treatment, a PWS should determine concentrations and proportions of species of chromium to select proper media or chemical aid.

SDWA 1996 requires EPA to determine small system technologies for compliance purposes, i.e., technology designated as suitable for systems serving 25 to 10,000 persons. In 1998 EPA listed the following compliance technologies for small systems: IX, LS (Cr III only), CF, RO, Point-of-Use (POU)-RO and POU-IX [USEPA, 1998b].

Due to the high efficiencies of chromium removal by the above technologies, EPA believes that existing BATs would be adequate in meeting a revised standard (if the standard were lowered). Thus, the preliminary assessment is that treatment technology would not pose a limitation should EPA pursue a revision to the chromium standard.

Due to recent interest by the State of California in setting a drinking water standard for Cr VI, the toxic form of chromium, that State as well as others have initiated treatment studies to determine the efficacy of treatment technologies in removal of Cr VI. Newer treatments of interest include an iron-based absorptive filter medium, granular ferric hydroxide (GFH), a technology that has been piloted for arsenic removal at California water systems, and in the United Kingdom. A treatment to reduce low levels of Cr VI to Cr III in drinking water by addition of the chemical stannous chlorine (SnCl_2) is currently under investigation at the Glendale, California water system. EPA will monitor treatment studies to determine acceptability for use in removal of chromium in drinking water.

Additional information:

Of additional interest to EPA is the likelihood that disinfection treatment, including chlorination, plays a role in transforming, by oxidation, Cr III to Cr VI in water. The EPA Manual of Treatment Techniques (USEPA, 1977) and the EPA Occurrence and Exposure report for Chromium (USEPA, 1990) discussed the effect of prechlorination on Cr III removal by coagulation, and the underlying effect of free residual chlorine on oxidation of Cr III to Cr VI. In the 1977 report, tests were cited in which a low chlorine dosage, 2 mg/L, with up to 6 hours, contact time, lowered Cr III removals by 10 percent using alum and ferric sulfate treatment; and,

that with contact extended to about 20 hours, alum treatment removals dropped to less than 10 percent of the more effective removals. In the latter (1990) report, EPA cites Ulmer (pre-publication report) in testing Cincinnati tap water: 4 samples of water, at pH levels 5, 6, 7, and 8, containing added Cr III at 0.462 mg/L. With an adjusted initial free residual chlorine level of 2 mg/L, after 30 minutes of contact, at the four pH levels cited, the investigator found that 1.5%, 4.0 %, 3.7% and 2.7% of the added Cr III had been oxidized to Cr VI; after 24 hours, 27%, 43%, 30% and 21% of the added Cr III had been oxidized to Cr VI in the same samples at the 4 respective pH levels. Time of contact between chlorination treatment and water tap varies greatly among systems. The above-cited chlorination tests represent a wide range of plausible contact times, including water storage, i.e., from 30 minutes to 24 hours. In addition, the above-referenced testing at Glendale, California of SnCl_2 as a Cr VI mitigation treatment includes investigation of re-oxidation of Cr III to Cr VI under various chlorination and ammoniation treatment disinfection scenarios.

The Health Canada criteria summary on chromium in drinking water also indicates some uncertainty in regard to whether post-treatment chlorination and conversion of residual Cr III to Cr VI may reverse in passage through iron pipes in distribution (Health Canada, 1986).

The above information provides a minimum baseline of information on potential transformations of Cr III to Cr VI, and treatment effects; more information may be required regarding these and other potential treatment effects.

In regard to small system technologies, EPA would review available information on newer potential treatments as research and field studies are undertaken and publicized. EPA may also need additional data on issues related to ion exchange POU treatment, which was discussed in a January 2001 (arsenic) EPA notice [USEPA, 2001]. It is not known if IX-POU will be a feasible compliance option, due to operational and waste discharge concerns and related economic issues.

Potential in-place treatment modifications:

EPA has previously published analyses of data collected in the 1995 Community Water System Survey (CWSS), on treatment in place at community water systems [USEPA, 2000a]. The data indicate that a majority of larger systems and mainly surface water supplied systems are much more likely to have CF or LS treatment in place. Some of these systems may need to modify existing treatment to allow for more efficient removal of chromium to comply with a more stringent chromium standard. For example, an existing LS plant may need to enhance the process to operate at a pH of 11 to 11.5 for optimum removal; or an existing CF plant may need to change to ferric or ferrous coagulant aid to lower chromium levels in drinking water. The CWSS data also indicate that small systems would more likely face modifying, or adding new, treatment, centrally or installing POU treatment, to meet a standard.

The option of modifying existing treatment may be possible for a limited number of systems, as 0.7% to 4.6% of small groundwater systems currently have IX treatment in place, and most of

these are likely to be cationic resin types (whereas anionic resins may be required to remove excess chromium); virtually none of the small surface water supplies have this treatment in place. 1.5% to 8.1% of small groundwater systems currently have CF or LS treatment in place; and, a large percentage of small (and nearly all large) surface water supplies have either CF or LS treatment in place. However, given the occurrence information, it appears that the majority of treatment upgrades would occur at small groundwater systems, many requiring new treatments, possibly pressurized, packaged treatment technology or other emerging treatments mentioned above

Tables 2a. and 2b. below contain results of the above-cited 1995 CWSS data analyses and are provided for reference.

TABLE 2 a. Groundwater Systems: Percentage (%) of CWSs with Various Types of Treatment In-Place

Treatment Types (CWSS 1995 Information)	Service Population Category				
	25-100	101-5000	501-1,000	1,001-3,300	3,300-10,000
Ion Exchange Treatment	0.7	1.6	3.8	1.9	4.6
Coagulation/Filtration	1.5	5.4	4.2	3.4	8.1
Lime/Soda Ash Softening	2.1	3.7	4.1	5.2	7.0

(Source: USEPA, 2000a. *Geometries and Characteristics of Public Water Systems*)

TABLE 2 b. Surface Water Systems: Percentage (%) of CWSs with Various Types of Treatment In-Place

Treatment Types (CWSS 1995 Information)	Service Population Category				
	25-100	101-5000	501-1,000	1,001-3,300	3,300-10,000
Ion Exchange Treatment	0	0	0	0	0
Coagulation/Filtration	27.5	52.6	70.2	78.5	95.4
Lime/Soda Ash Softening	3.9	8.1	20.5	17.5	10.8

(Source: USEPA, 2000a. *Geometries and Characteristics of Public Water Systems*)

Potential chromium treatment research:

Prior to conducting analyses in support of a NPDWR revision, EPA review of literature and/or new treatment research may be required. This may include documentation of bench, pilot, and/or full-scale studies on granular ferric hydroxide, other adsorption media, and membrane technologies. POU -IX studies on chromium removal may be required, including tests on efficacy of treatment and disposal of related wastes. Studies may include optimization of centralized IX treatment efficiency and waste treatment and handling/disposal. Effects of disinfection treatments, as well as addition of reducing agents such as SnCl_2 , on chromium in water may require further study should a more stringent chromium MCL be considered. These needs may be forwarded within EPA for potential research.

FLUORIDE

Treatment technology:

Recent EPA occurrence analyses indicate fluoride occurrence in public water systems based on a sampling of 16 States [USEPA 2002, *draft*]. Based on these analyses which included estimated system mean concentrations, EPA estimates indicate that 106 water systems (credible interval of 91-123) within these States may exceed the threshold of 4 mg/L, i.e., the current MCL for fluoride; in addition, EPA estimates indicate a total 603 (credible interval of 566-640) water systems within these States may exceed the threshold of 2 mg/L. Additional occurrence estimates may be found in the above-cited 2002 EPA draft report.

The 1986 final fluoride regulation set “best technologies generally available” (BTGA) as activated alumina (AA) and reverse osmosis (RO). BTGA was defined prior to the SDWA Amendments of 1986, and was based upon measures of technological efficiency and economic availability (i.e., “reasonably affordable by regional and large metropolitan public water systems”). The following factors were considered in determination of BTGA: high removal rate; wide applicability; compatibility with other treatments; and ability to achieve compliance for all water in the PWS [USEPA, 1986]. These requirements are comparable with current SDWA requirements for BAT determination.

In addition, SDWA 1996 requires EPA to determine small system technologies for compliance purposes, i.e., technology designated as suitable for systems serving 25 to 10,000 persons. In 1998 EPA listed small system compliance technologies, including both AA and RO treatment for removal of fluoride in drinking water; EPA also included POU- RO treatment as a small system compliance technology for fluoride [USEPA, 1998].

Pending completion of the subject review of NPDWRs, the Agency may decide to reset the fluoride BATs including those that were set in 1986 as ‘BTGA.’ This may or may not occur along with a more substantive revision to the standard, and would represent a minor revision. The pertinent sections of US Code are §141.62, MCLs for Inorganic Contaminants, and §142.61 which specifies variance technologies for fluoride [US CFR, Part 141 and Part 142].

Previously published research and EPA technologies and costs documents [USEPA 1984] on these technologies indicate that, due to high efficiencies of removal, the above-cited treatment technologies would not be a limiting factor in setting a lower fluoride MCL. Efficiencies of removal range from 85% to 95%, depending upon treatment system design. Thus, the preliminary assessment is that treatment technology would not pose a limitation should EPA pursue a revision to the fluoride standard.

Both AA and RO treatment remove arsenic *and* fluoride among other impurities. Using AA treatment, optimum removals for both contaminants may occur in a similar range of pH 5.5 to pH 6 [USEPA, 1985; US EPA, 2000b]. However, because arsenic-V and silica are

preferentially adsorbed by AA media, effectiveness of AA where arsenic and fluoride co-occur may require some investigation. Another AA treatment shortcoming, discussed further below, is the operational difficulty of adding pH adjustment for optimizing removal efficiency (i.e., adjusting pH prior to and after treatment). For some small systems treatment may be limited to using ‘*natural*’ pH levels (i.e, unadjusted) thus sacrificing some removal efficiency; however, this application for fluoride removal is not documented).

Technical issues related to AA technology were discussed in the above-cited fluoride final rule. These included waste generation and disposal. More recent EPA publications have also examined the operation of AA technology and perceived difficulties posed by chemical handling, i.e., for pH adjustment and for regeneration of the media, by small systems, as well as the alternatives to regeneration of AA media. In the case of arsenic treatment, it was decided that regeneration of AA media at both small centralized treatment and POU applications would not be recommended, due in part to the difficulty of disposing of brine wastes (additional rationale is cited below). EPA instead assumed that spent AA media would be disposed of directly at a landfill on a ‘throw-away’ basis and that, based upon arsenic TCLP testing, this waste would not be deemed ‘hazardous’ [USEPA, 2000b and USEPA, 2001]. However, except where arsenic and fluoride were being co-treated, this information should not (alone) be applied to fluoride treatment wastes because RCRA regulations do not regulate fluoride under the Toxicity Characteristic hazardous waste identification rule (40 CFR 261.24). That stated, there may be concerns regarding waste brine, i.e., regenerate solution, that have not yet been anticipated.

Recent activity on the arsenic standard also addressed the issues of treatment optimization (pH adjustment) at AA POU. For arsenic it was determined that use of AA POU (and POE) would be limited due to the practical limitation of adjusting pH and then re-adjusting following treatment for corrosion control. The option of using AA at an *unadjusted* ‘natural pH’ range of 7 to 8 was discussed as the probable application at *very* small systems due to the operational capabilities that are required [USEPA, 2000b and USEPA, 2001].

While not currently a ‘BTGA’ or ‘BAT’, modified lime softening (30-70% removal) may also be used where this treatment is in place, to remove excess fluoride [USEPA, 1985, T&C].

The following summarizes additional information that may relate to setting, revising, and/or application of the above two BATs and the POU compliance option for fluoride.

Potential in-place treatment modifications:

Cost of treatment may drive systems above the compliance level to the less expensive option, i.e., activated alumina, or to newer treatments as they become available. Where de-fluoridation treatment is already in place, due to prior exceedance of the current F MCL, systems may opt to increase the proportion of water treated, or add more *capacity* to existing treatment (or add additional media vessels in series). Where a centralized treatment may be less feasible, some very small systems may install POU treatment (RO more likely) which may present operational advantages and additional treatment benefits. The BATs are known to remove fluoride and

arsenic (As V is preferentially adsorbed by AA media); RO treatment would remove additional regulated and secondary contaminants such as total dissolved solids, hardness, iron, and manganese, which may co-occur with fluoride in water.

EPA's 1995 Community Water System Survey data is summarized and has been utilized in recent EPA technical support materials [EPA 2000a (*Geometries of PWS*), and the USEPA *Baseline Handbook, Draft*]. These provide some understanding of numbers and types of treatments in place at community systems; however, they do not specifically include AA treatment information. Therefore it is not possible to estimate a relationship between systems now treating with AA and those that may need to treat further to meet a lower standard (however, in areas with high background levels (especially if above 4 mg/L), treatment of fluoride may already be in place). The followup 2000 Community Water System Survey results are expected to include AA treatment information and these will be available in early 2002.

The CWSS summary tables indicate (see Tables 2a. and 2b.) that existing lime/soda ash softening capacity exists and *may provide*, especially for surface water systems, a base for increased fluoride removal via enhanced lime softening treatment.

Potential fluoride treatment research:

Prior to conducting analyses in support of a NPDWR revision, EPA review of literature and/or new treatment research may be required. This may include documentation of bench, pilot, and/or full-scale studies related to AA de-fluoridation treatment effectiveness at natural vs. adjusted pH levels, with and without competition from arsenic V. Documentation of bench, pilot, and/or full-scale engineering studies on other adsorption treatment processes may be required. Documentation and/or study of waste treatment, handling and disposal, and POU treatment studies, may also be required should a more stringent fluoride MCL be considered. These needs may be forwarded within EPA for potential research.

OXAMYL

Recent EPA occurrence analyses indicate oxamyl occurrence in public water systems based on a sampling of 16 States [USEPA 2002, *draft*]. Based on these analyses which included estimated system mean concentrations, EPA estimates indicate zero (in number and percent) water systems within these States exceed the threshold of 0.2 mg/L, i.e., the current MCL for total oxamyl. Additional occurrence estimates may be found in the above-cited 2002 EPA draft report.

The current BAT is granular activated carbon (GAC), and removal efficiency ranges from 85% to 95% depending upon design parameters [USEPA, 1990a, 1990c, 1992]. Compliance technology for small systems includes GAC, powdered activated carbon (PAC), and POU-GAC [USEPA, 1998b].

If water treatment systems were to require upgrading, additional GAC contactor(s) may be added or PAC added, as appropriate. Given available information on treatment efficacy and on

occurrence levels, the preliminary assessment is that treatment technology would not pose a limitation should EPA pursue a revision to this standard.

PICLORAM

Recent EPA occurrence analyses indicate picloram occurrence in public water systems based on a sampling of 16 States [USEPA 2002, *draft*]. Based on these analyses which included estimated system mean concentrations, EPA estimates indicate zero (number and percent) water systems within these States exceed the threshold of 0.5 mg/L, i.e., the current MCL for total picloram. Additional occurrence estimates may be found in the above-cited 2002 EPA draft report.

The current BAT for picloram removal is GAC treatment. Treatment technologies were discussed by EPA in its technical support documentation [USEPA 1990a, 1990c, 1992]. Small systems compliance technologies are GAC, powdered activated carbon (PAC), and POU GAC [USEPA, 1998b].

If treatment were to require upgrading, additional GAC contact units may be added or POU treatment installed. Given available information on treatment efficacy and on occurrence levels, the preliminary assessment is that treatment technology would not pose a limitation should EPA pursue a revision to this standard.

Where treatment is currently in place, for this contaminant and possibly for others, it is likely to be operating and valued for other beneficial effects, e.g., for reduction of other organics or other common impurities. However, EPA does not have data indicating to what extent this may occur and thus its significance, therefore the Agency is making no assessment as to whether treatment in place would be maintained or discontinued in the event of the MCL for picloram being revised.

III. Treatment review for chemical contaminants controlled by treatment technique (TT) requirements

ACRYLAMIDE and EPICHLOROHYDRIN

EPA regulations for these two contaminants, including technology-related polymer addition practices, were discussed in *Federal Register* notices of 1989 and 1991 [USEPA 1989, USEPA 1991a]. EPA has no new information that suggests it is appropriate to revise the TT requirements for acrylamide and epichlorohydrin at this time.

LEAD AND COPPER RULE

The Lead and Copper Rule (LCR) [USEPA 1991b] relates to the mitigation of lead and copper in public drinking water supplies through treatments, mainly through optimizing corrosion control treatment and through related monitoring strategies.

The LCR establishes treatment-type measures to control levels of lead and copper in public drinking water, including corrosion control treatment requirements for small, medium and large water systems. Treatment may be triggered following sampling and analysis of tap water that suggests an exceedance of the lead or copper action levels, 0.015 mg/L and 1.3 mg/L (90th percent levels), respectively.

Under the LCR, PWS corrosion control studies are required to evaluate the effectiveness of each of the following treatments and if appropriate combinations of the following treatment:

- alkalinity and pH adjustment
- calcium hardness adjustment
- addition of a phosphate or silicate based corrosion inhibitor.

PWS are also required to measure the following water quality parameters, before and after evaluating the above treatments: lead, copper, pH, alkalinity, calcium, conductivity, orthophosphate or silicate (where added), and water temperature. Water systems must identify constraints that limit or prohibit the use of a particular corrosion control treatment(s), and evaluate effect(s) of corrosion control chemicals on other water quality treatment processes. On the basis of the above, a PWS recommends the treatment option best suited for its system, and the State review agency considers the PWS information then designates optimal treatment for that system.

EPA has no information that suggests it is appropriate to revise the current TT requirement for lead and copper.

Issues related to implementation of LCR, such as record keeping and reporting requirements, are addressed in a separate EPA document and do not directly contribute to the subject review of treatment related to the LCR.

However, EPA suggests that exploratory-type research on treatment aspects of the LCR, i.e., on effective corrosion control measures, may be appropriate.

Among potential LCR-related research areas are the following:

1. Improving corrosion control treatment and determination of treatment ‘optimization’ in cases where high alkalinity and/or high hardness in source water may result in copper exceedences.
2. Studying possibilities of targeted monitoring for control of copper under certain conditions. Problems have been cited by various entities: EPA Regions and State regulators.
3. Determining whether use of a chemical marketed as a corrosion inhibitor, i.e., stannous chloride, produces positive and measurable effects related to LCR compliance. Possible research areas include: investigation of effectiveness of LCR monitoring (i.e., how and what parameter(s) to monitor for optimum performance); and, investigation of potential secondary effects of this chemical, including effects on disinfectant chlorine residuals in distribution system [Note: effects related to addition of stannous chloride as a reducing agent are also cited in an earlier section on chromium treatment].
4. Determining relationship of disinfection and oxidation treatments, such as for iron and manganese control, and age of plumbing material on copper levels in water and/or lead scale in distribution systems.
5. Gathering of information on Pb(IV) solids which may be found in pipe films, to determine if and how ‘optimization’ occurs; other treatments may impact Pb(IV) solids and require clarification. Pb(IV) occurrence levels are not well characterized. Research would improve predictive ability in this regard.
6. Determining additional treatment effects on LCR corrosion control: these may include investigation of aluminum and/or phosphate deposition in distribution in relation to corrosion control treatment(s); investigation of long-term impacts of the use of silicates in lieu of phosphates in corrosion control treatment (due to contemporary wastewater concerns); investigation of optimizing iron and manganese control with lead and copper control; and, investigation of effects on corrosion control by DBP precursor removal aids, i.e., in switching coagulants from alum to ferric type.

IV. Treatment review for chemical contaminants for which current MCL is limited by analytical feasibility and EPA analytical feasibility analyses suggest a potentially lower practical quantitation level (PQL)

NOTE: For *all* contaminants discussed in this section the preliminary assessment is that treatment technology would not pose a limitation should EPA pursue a revision to any of the referenced standards. Chemical occurrence is not referenced since the known occurrence levels would not pose an obstacle to treatment specification.

Volatile Organic Contaminants:

BENZENE

The current MCL for this contaminant is 0.005 mg/L. Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for benzene, EPA has reviewed treatment feasibility. BAT for benzene includes both PTA and GAC [USEPA 1991a]. EPA listed the following small systems compliance technologies for benzene: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC [EPA 1998b].

Treatment for VOCs was discussed in the 1985 EPA proposal [USEPA 1985]. Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, while 99 percent reduction may be considered reasonable engineering practice. The above-cited EPA proposal also discussed GAC treatment for VOCs, with a reasonable engineering assumption of 99 percent removal capability. Treatment is not known to be a limiting concern for the current MCL.

Based on the above information, the preliminary assessment is that treatment technology would not pose a limitation should the Agency consider revising the current MCL.

CARBON TETRACHLORIDE

The current MCL for this contaminant is 0.005 mg/L. Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for carbon tetrachloride, EPA has reviewed treatment feasibility. BAT for carbon tetrachloride includes both PTA and GAC [USEPA 1985]. EPA listed the following small systems compliance technologies for carbon tetrachloride: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

Treatment for VOCs was discussed in the 1985 EPA proposal [USEPA 1985]. Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, while 99 percent reduction may be considered in reasonable engineering practice. The above-cited *Federal Register* Notice also discussed GAC treatment for VOCs, with a reasonable engineering assumption of 99 percent removal capability. Based on the above information, the preliminary assessment is that treatment technology would not pose a limitation should the Agency consider revising the current MCL.

1,2-DIBROMO-3-CHLOROPROPANE (DBCP)

Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for DBCP, EPA has reviewed treatment. BATs include aeration and GAC [USEPA 1989 and USEPA 1991a]. Compliance technologies for small systems include GAC, PAC, and POU-GAC [EPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

Since the Henry's coefficient for this contaminant is relatively low (i.e., 7 atm DBCP which is considered 'less strippable' than other contaminants), GAC may in some cases be the preferred treatment. Based on the above information, the preliminary assessment is that treatment technology would not pose a limitation should the Agency consider revising the current MCL.

1,2-DICHLOROETHANE (Ethylene Dichloride)

Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for 1,2-dichloroethane, EPA has reviewed treatment feasibility. BATs for 1,2-dichloroethane includes both PTA and GAC [USEPA 1985]. EPA listed the following small systems compliance technologies for this contaminant: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

Treatment for VOCs was discussed in the 1985 EPA proposal [USEPA 1985]. Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, while 99 percent reduction may be considered in reasonable engineering practice. The above-cited *Federal Register* Notice also discussed GAC treatment for VOCs, with a reasonable engineering assumption of 99 percent removal capability. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

DICHLOROMETHANE (Methylene Chloride)

Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for dichloromethane, EPA has reviewed treatment feasibility. As a volatile organic contaminant (VOC), BAT for dichloromethane is PTA [USEPA 1992]. EPA listed the

following small systems compliance technologies for dichloromethane: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and granular activated carbon (GAC) [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

Treatment for VOCs was also discussed in a 1985 EPA proposal [USEPA 1985]. Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, while 99 percent reduction may be considered reasonable engineering practice. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

1,2-DICHLOROPROPANE

Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for 1,2-dichloropropane, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. BATs for 1,2-dichloropropane includes both PTA and GAC [USEPA 1989 and USEPA 1991a]. EPA listed the following small systems compliance technologies for this contaminant: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

Among volatile contaminants, this contaminant exhibits ‘average strippability’ [USEPA 1989]. Treatment for VOCs was also discussed in the 1985 EPA proposal [USEPA 1985 (pp. 46909-46916)]. Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, while 99 percent reduction may be considered in reasonable engineering practice. The 1985 *Federal Register* Notice also discussed GAC treatment for VOCs, with a reasonable engineering assumption of 99 percent removal capability. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

TETRACHLOROETHYLENE (“Perc”)

Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for tetrachloroethylene, EPA has reviewed treatment feasibility. BAT for tetrachloroethylene includes packed tower aeration (PTA) and granular activated carbon (GAC) [USEPA 1991a]. EPA listed the following small systems compliance technologies for tetrachloroethylene: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

The high level of volatility of tetrachloroethylene is reflected in this chemical’s Henry’s Law Coefficient of 214.0 atmospheres. Design of air stripping equipment was discussed in the proposal for this NPDWR. Several factors which effect engineering design include: air-to-water ratio; packed material height; available area for mass transfer; water and air temperature; and,

physical chemistry of the contaminant [USEPA 1989 (p. 22118)]. Tetrachloroethylene, while volatile, is also highly amenable to GAC adsorption treatment. Carbon use rates for this contaminant are relatively low. Treatment for VOCs was also discussed in the 1985 EPA proposal [USEPA 1985 (pp. 46909-46916)]. Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, while 99 percent reduction may be considered in reasonable engineering practice. The 1985 *Federal Register* Notice also discussed GAC treatment for VOCs, with a reasonable engineering assumption of 99 percent removal capability.

Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

TRICHLOROETHYLENE

Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for trichloroethylene, EPA has reviewed treatment feasibility. BAT for trichloroethylene includes both PTA and GAC. EPA listed the following small systems compliance technologies for trichloroethylene: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, spray and mechanical aeration, and GAC [EPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

Treatment for VOCs was discussed in the 1985 EPA proposal [USEPA 1985]. Under optimum conditions, up to 99.9 percent removal of VOCs may be achieved by aeration technology, while 99 percent reduction may be considered reasonable engineering practice. The above-cited *Federal Register* Notice also discussed GAC treatment for VOCs, with a reasonable engineering assumption of 99 percent removal capability. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

Other Organic Contaminants and Thallium:

CHLORDANE

BAT for chlordane is GAC [USEPA 1991a]. Treatment is not known to be a limiting concern for the current MCL. However, since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for chlordane, EPA has reviewed treatment feasibility. Chlordane is a moderately adsorbed pesticide [USEPA 1989 and USEPA 1991a], therefore the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

HEPTACHLOR

BAT for heptachlor is GAC [USEPA 1991a]. EPA listed the following small systems compliance technologies for heptachlor: GAC, POU-GAC, and PAC [USEPA 1998b]. Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for heptachlor, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

Heptachlor is a moderately adsorbed organic contaminant [USEPA 1989 and USEPA 1991a]. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

HEPTACHLOR EPOXIDE

BAT for heptachlor epoxide is GAC [USEPA 1991a]. Compliance technologies for small systems include GAC, PAC, and POU-GAC [USEPA 1998b]. Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for heptachlor epoxide, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

Heptachlor epoxide is a strongly adsorbed organic contaminant, generally attributed to a low carbon usage rate [USEPA 1989 and USEPA 1991a]. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

HEXACHLOROBENZENE

BAT for hexachlorobenzene is GAC [USEPA 1992]. Compliance technologies for small systems include GAC, PAC, and POU-GAC [USEPA 1998b]. Since the results of the analytical methods feasibility review suggests that it may be possible to recalculate the PQL for hexachlorobenzene, EPA has reviewed treatment feasibility to determine if it is likely to become an issue if EPA were to revise the MCL. Treatment is not known to be a limiting concern for the current MCL.

Since hexachlorobenzene is a moderately adsorbed contaminant, based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

THALLIUM

BATs for thallium include activated alumina (AA) and ion exchange (IX) [USEPA 1992]. EPA also listed small systems compliance technologies for this contaminant as AA, IX, POU-IX [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

According to technical information provided previously by EPA for thallium, competing ions in water may affect treatment run lengths [USEPA 1998b]. Given reasonable engineering practice, high removals of this contaminant are feasible. Removals may be expected to be greater than 90% using cation exchange systems, and greater than 95% using AA treatment [USEPA 1990c]. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

TOXAPHENE

BAT for toxaphene is GAC [USEPA 1991a]. EPA also listed small systems compliance technologies for this contaminant as GAC, POU-GAC, and PAC [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

According to technical information provided with the final NPDWR for toxaphene, this compound is among those that are moderate to well-adsorbed, exhibiting a relatively low carbon usage rate [USEPA 1989 and USEPA 1991a]. Given reasonable engineering practice, high removals of this contaminant are feasible. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

1,1,2-TRICHLOROETHANE

BATs for 1,1,2-trichloroethane includes both PTA and GAC [USEPA 1992]. EPA listed the following small systems compliance technologies for this contaminant: PTA, diffused aeration, multi-stage bubble aerators, tray aeration, shallow tray aeration, and GAC [USEPA 1998b]. Treatment is not known to be a limiting concern for the current MCL.

According to technical information provided by EPA within the final NPDWR for 1,1,2-trichloroethane, this compound is among those moderately adsorbed chemicals, exhibiting an moderate carbon usage rate. 1,1,2-trichloroethane may be among the less volatile organic chemicals [USEPA 1990c]. Given reasonable engineering practice, treatment for removal of this contaminant is feasible. Based on the above information, the preliminary assessment is that treatment technology is not anticipated to pose a limitation should the Agency consider revising the current MCL.

V. Contaminant for which BAT is not clear or incorrectly specified

CYANIDE

BATs for cyanide include ion exchange, reverse osmosis, and “chlorine” treatment, according to the US Code of Federal Regulations [US CFR]. A revision such as a technical amendment to the NPDWRs for cyanide may be required in regard to the above-stated “chlorine” treatment BAT. CFR §141.62, which contains BAT information which is also cited in §142.62 (variances and exemptions), should read “alkaline chlorination” in lieu of “chlorine” as a BAT for cyanide.

Chlorination was discussed in EPA’s proposal for the cyanide standard, and in the final rule announcement [USEPA, 1990c and 1992, respectively]. The effectiveness of oxidation of cyanide at high pH was discussed in the pertinent technology support document [USEPA, 1990b].

In addition, since this standard was promulgated, a “Public Water System Warning” [USEPA, 1994] was distributed by EPA through its regional offices. This warning included information on the use of chlorination (non-alkaline) and the potential for formation of harmful cyanogen chloride, due to reaction of chlorine with cyanide in water under those conditions. NOTE: this Warning also states, “EPA will change the regulations specifying BAT for removing cyanide from chlorination to alkaline chlorination.”

Alkaline chlorination, through use of excess chlorine at pH values greater than 8.5, oxidizes cyanide to harmless bicarbonate and nitrogen gas. The higher the pH, the faster this reaction proceeds. The above-cited PWS warning explains this process in detail and outlines treatment practice, including contact times, required chlorine concentrations, and compensation for temperature effects.

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